NASA TECH BRIEF

High Strength Nickel-Base Alloy with Improved Oxidation Resistance up to 2200°F

The problem:

To provide a high strength, workable nickel base "superalloy" with improved oxidation resistance for use up to 2200°F.

The solution:

Modifying the chemistry of the NASA TAZ-8 alloy and by utilization of vacuum melting techniques. The strongest of the nickel base superalloys developed by NASA is designated TAZ-8 and has the following composition in weight percent: 6 chromium, 6 aluminum, 4 molybdenum, 8 tantalum, 4 tungsten, 2.5 vanadium, 1 zirconium, 0.125 carbon, and a balance of nickel. This basic formulation has been modified by substituting 2.5% columbium for the vanadium constituent and also by the addition of 0.004% boron. This new nickel-base alloy, designated TAZ-8A, generally retains the good elevated temperature strength of TAZ-8, is workable, and has excellent high temperature oxidation resistance.

How it's done:

Of the elements present in TAZ-8, vanadium was considered to be one of those most likely to adversely affect its oxidation resistance. Consequently, it was removed and replaced by another strengthener, columbium. Columbium forms carbides and also combines with nickel to form a relatively high melting point intermetallic compound. Boron which has beneficial effects on the stress-rupture life and hot workability of some nickel-base alloys was also added.

After 310 hours exposure to air at 1900°F, TAZ-8A had a weight gain of 1.8 mg/cm^2. The depth of the total affected zone, external oxide scale plus depletion zone, was 0.4 mil. This compares with a weight gain of 3.0 mg/cm^2 and a total affected zone depth of 3.3 mils for René 41 (a leading representative commercial nickel-base alloy), after only 100 hours exposure at 1900°F. In sheet form, its oxidation resistance after 8 hours at 2200°F was approximately the same as that of René 41 at 1900°F.

Tensile strengths of TAZ-8A after rolling and heat treatment ranged from an average of 185,000 psi at 1400°F to 3000 psi at 2200°F. Maximum elongation was 55 percent and occurred at the latter temperature. At 1900°F, the average tensile strength was 64,500 psi in the as-cast condition, and 54,000 psi after rolling and heat treatment.

Stress rupture data for low and intermediate stress levels were obtained in the as-cast condition. Use temperatures for 500-, 100-, and 10-hour life at 15,000 psi are 1815°, 1895°, and 2010°F, respectively. At 8000 psi and 2125°F, rupture life was 13 hours and compared favorably with some of the strongest-known nickel- and cobalt-base alloys.

Notes:

1. The very good high temperature oxidation resistance, good high temperature strength, and at least limited workability of this alloy suggest that it may be applicable for use in advanced gas turbine engine components, although this alloy need not necessarily be limited to gas turbine applications.
2. Further general information concerning the subject of nickel-base and cobalt-base superalloys is given in NASA Tech Brief 66-10222, NASA Tech Brief 63-10351, and NASA Technical Note D-2495, available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

(continued overleaf)

3. Additional details are contained in:

(a) NASA Technical Note D-3597, *Investigation of Columbium-Modified NASA TAZ-8 Superalloy,* by W. J. Waters and J. C. Freche, Lewis Research Center, Cleveland, Ohio, September 1966. Copies of this report are available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151; price $3.00.

(b) *A High Strength Nickel Base Alloy with Improved Oxidation Resistance Up to 2200°F,* by W. J. Waters and J. C. Freche (soon to be published in ASME Transactions—Journal of Engineering for Power, paper no. 67-GT-1).

4. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135
Reference: B68-10094

Patent status:

This invention has been patented by NASA (U.S. Patent No. 3,276,866) and royalty-free license rights will be granted for its commercial development. Inquiries about obtaining a license should be addressed to NASA, Code GP, Washington, D.C. 20546.

Source: W. J. Waters and J. C. Freche
(LEW-10115)